COMPARISON OF PEDESTRIAN FUNDAMENTAL DIAGRAMS THROUGH EXPERIMENT AND FIELD OBSERVATIONS

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By

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CERTIFICATE

I hereby certify that the work which is being presented in the thesis entitled, "**COMPARISON OF PEDESTRIAN FUNDAMENTAL DIAGRAMS THROUGH EXPERIMENT AND FIELD OBSERVATIONS**"in partial fulfillment of the requirements for the award of **Master of Technology** Degree in **Transportation Engineering** submitted in the department of **Civil Engineering** at **National Institute of Technology, Rourkela** is an authentic record of my own work carried out under the supervision of **Dr.U. Chattaraj** Assistant Professor, Civil Department.

The matter presented in this thesis has not been submitted for the award of any other degree of this or any other national or international level institute/university.

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ABSTARCT

Walking is the simplest form of transportation and yield basic mobility.Various empirical studies and a series of experiments have done to understand pedestrian dynamics. As pedestrians are the most vulnerable road users, prediction of pedestrian movements is valuable in many contexts. Pedestrian behave differently under different situations.Different factors like age, gender and gender mix conditions are considered in this thesis. The data collected in both field and experimental study with respect to these above mentioned factors i.e like age, gender and gender mix conditions . This study was directed in two stages, In the first stage, we led the studies and the related research works on pedestrian movement in different spaces or locations i.e collection of field data and its representation of fundamental diagrams and review of the behavior that is influenced by environment and other factors. In the second phase, puts forth to describe the pedestrian motion in experimental observation which was conducted under ideal , the absence of uncontrollable disturbing factors such as side by side pedestrian movement, tail back effect and overtaking etc.,the experimental set up for simple single file pedestrian flow with boundary condition. Various disturbing factors are avoided in the experimental studies.Differences of pedestrian flow in between field observation and conducted experimental observation are studied through hypothesis testing.

Keywords :Pedestriandynamics, fundamental diagram,hypothesis test.

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CHAPTER 1

INTRODUCTION

1.1 Background

In India the level of versatility in urban and in addition, provincial areas has expanded because of the creation of more mechanized and non-mechanized vehicles.Most of the travel has been proficient by the vehicles yet there are sure places where we need to stroll to achieve our destination.The most fundamental and primary form of human mobility is walking,which is a vital factor for the progress towards human civilization. Human's first mean of transportation is walking. Most of the trips by other type of modes may either begin or end with walking. Although motorized transportation has priority over all other types of transportation systems, but pedestrian flow plays an important consideration in many areas like planning of urban systems, traffic forecasting and operations, land use planning, designing of important public architectures. Better mobility can be provided if there is clear understanding of pedestrian flow. In case of vehicular traffic, separate directions are provided for vehicles by lanes and flow is regulated, whereas pedestrian move in multi direction depending up on their own choice and purpose of the trip etc.The pedestrian flow can be unidirectional or single file motion(where pedestrian movement is in one direction, space between pedestrians in the direction of motion affects pedestrian speed,) or bi-directional(where direction of movement is in both direction).Pedestrian movement is highly vulnerable, chaotic and complex in nature. A pedestrian tries to have a most convenient way for movement, So that delays can be minimized by avoiding obstacles and other passing by pedestrians, meant to use an optimal path to attain the destination at a certain time. How pedestrian behave in different situations, they need of space to move, etc. are very

important for the designer to understand for creating urban places with better mobility. Most of the time pedestrian's behaviors are same under similar type of average conditions where as pedestrians can vary their own speed and try to have the spaces within the walking area. Management of pedestrian movement within the public facilities can be easier by proper knowledge of pedestrian flow characteristics and the walking behavior of the pedestrian underlying the characteristics. Well planned improved and newtypes of pedestrian facilities acquire safe mobility and greater access. A friendly environment for the pedestrians is an important factor for encouraging walking as travel mode, and,which is beneficial for health and environmental by reducing air pollution.Since 1950 there are many observations were devoted for pedestrian flow dynamics. Under some typical condition such as a panicking state during jamming and evacuation out of any room or hall, clogging at exit, where most of the time the tragic accidents and disaster occurs, it is necessary to study pedestrian flow. Empirical pedestrian data analysis amassed by pedestrian tracking ,which explains the essential forms of pedestrian dynamics .Besides the empirical data analysis, several types of studies have done to have the quantitative pedestrian data analysis. Many researches were aiming at realistic representation of the pedestrian flow and movement behavior. Based on empirical data several studies by researchers have performed to acquire thequantitative analyses of pedestrian flow characteristics. Pedestrian flow can be investigated with two types of basic models, i.e. microscopic and macroscopic models. The observables which are most commonly stated in pedestrian dynamics are speed, flow and density, in between these three characteristics a statistical relation exists which can be explained by fundamental diagram. The three pedestrian motion characteristics are interrelated(for examples level of service,fundamentaldiagram,capacity of the system and speed distribution).The mean speed (v) and the density (k) are measured as space mean values,

whereasthe flow rate (q) is measured as time mean value. The equilibrium equation in between these characteristics is q=v .k.The different types of fundamental diagram which are shown below.For designing of any type of pedestrian architectures or facility speed-density relation or the fundamental diagram plays an important role. The fundamental diagram varies with respect to different facilities such as bottleneck, stairs, hall and ramp. The dependence between the inverse of density, i.e. distance head way (the minimum space for movement) with the speed is one of the major considerations. The space required to move for pedestrian is related to the speed, at which pedestrians are moving.In field observation Various environmental factors such as the interaction between pedestrians, side by side walk, overtaking exists, which affects the walking characteristics average speed, density or distance headway, flow. . Furthermore the pedestrian motion is influenced by many other factors including cultural and regional differences, different characteristics of the pedestrians such as gender, age, size, health, mood, stress, carry baggage, surrounding environment (purpose of trip,triplength,safety, time of the day, period of the year),the ongoing variation of times, the behavioral pattern, body size and mass, and are also varying and affecting the characteristics of pedestrian motion.To understand the pedestrian flow various studies has performed under laboratory condition with experimental setup. The advantageof an experimental study is the controlled circumstances, both with observed situation and data collection condition, the investigation for the speed–density relation or the fundamental diagram is restricted to the normal condition where panic or pushy movement of pedestrians are avoided.A research facility analysis can be controlled by an analyst, not just concerning the conditions (light, climate), additionally to the quantity of people on foot and heading of streams. Due to a variety of experimental and observational conditions, the fundamental diagram also varies. In both field and experimental observation age and the gender

are two important factors. Age and gender of pedestrian impacts the pedestrian characteristics. Many efforts have been made by researchers to explain the effect of age and gender on pedestrian dynamics through the fundamental diagram.The difference between two studies can be studied through hypothesis testing,which refers to the procedure to accept or decline the statistical hypothesis.It is a procedure of picking between the contending observed samples with respect to the probability distribution,taking into account watched information from the conveyance.There are two sorts of hypothesis cases

1.Null Hypothesis: it is signified by $H_{0,}$where the two sample sets are accepted as same with no difference .

2.Alternative hypothesis:It is denoted by H_1 or $H_{a,}$where the observed samples are accepted to be different affected by some non-irregular reason.By computing the P-value,which denotes the probability of the test statics to significant or insignificant.P-valueobtains the outcome of the statistical test which varies from 0 to 1(none negative).Where significance level explains the decision based on the concerned value which is expressed in null hypothesis.If there is rejection of the null hypothesis,then it is accepted to reach the significance.If null hypothesis is retained then it is accepted to be the failure for reaching significance.Two types of decisioncan be made i.e either rejecting the null hypothesis where the mean of sample is related with a low probability of occurrence when the null hypothesis is true.or retaining the null hypothesis where the mean of smple is related with high probability of occurrence when null hypothesis is true.

1.2 Objective

This paper mainly analyzes the pedestrian flow characteristics (speed, density or distance headway and flow) by studying fundamental diagrams both in field observations and well-controlled experimental observations.The empirical data are collected, including field and well-controlled experimental studies on pedestrian dynamics.The results promote the understanding of pedestrian dynamics and also enrich the laws, standards and regulations for designing of any public facility. This thesis aimed at

- To collect various field data with respect to age and gender.

- To represent fundamental diagrams for data collected from field observation,(where data collection was done with respect to gender and age).

- Study the difference between field data and experimental data from Hypothesis testing

In the experimental study different group and gender of pedestrians is introduced for single file movement to understand the variation in speed and density, where the shape and size of the corridor is similar as mentioned in Chattaraj et al. (2009) for same experiment in Germany and India.

This thesis report is divided into five sections and this is the first section. The next section represents the past work done on pedestrian dynamics with various considerations and their reviews, where motivation of this thesis is expressed.

In chapter 3, the data collection procedure and data are described. Various governing factors for pedestrian, study are prescribed.

In chapter 4, the description of empirical studies to determine the pedestrian characteristics is given. Validation of analyzing data by summarizing obtained results from the comparison of observed results between field and experimental study of pedestrian motion.

In Chapter 5, the conclusion of the thesis is presented.

Chapter 2

Literature Review

Researches formed on pedestrian dynamics has given valuable knowledge to designer of public facility, and these studieshave helpedin better designing of facilities with safety and crowd management. The better understanding of factors affecting pedestrian dynamics requirement increase with the appearance of new well designed public facilities. The literature relating the past work done on pedestrian dynamics is presented in chapter 2.The empirical study or research on pedestrian dynamics at the present stage will be discussed. Based on this discussion, a brief review of existing theories, approaches and data is given.

2.1Empirical Studies on Pedestrian flow

Based on empirical data several studies on pedestrian flow have been performed to obtain the quantitative analysis of pedestrian flow characteristics. Mostly used observables are speed, flow and density. Many researchers have performed several studies and proposed statistical relationship between these pedestrian flow characteristics which is called as fundamental diagram, which is a major input for designing and planning of pedestrian facilities.Empirically Pedestrian flow has been studied from decades (; Hankin and Wright, 1958; Oeding, 1963, Hoel, 1968; Older, 1968; Navin and Wheeler, 1969; Fruin,1971, Weidmann (1993), Seyfried et al.(2005) and Helbing et al. (2007);). The procedure of data collection is different in each study. For designing and safety of any existing or proposed facilities the long accepted data,formulas with regulations,standards and handbooks are followed. For example,in United States Fruin's Dissertation, Designing for Pedestrians: A Level of Service Concept,(1970*)* and subsequent

books, Pedestrian Planning and Design, (Fruin, 1971, 1987*)* are followed as a prime source of data.

2.2. Literature Review on basic pedestrian flow:

Hankin and Wright (1958) established speed(m.p.h)- concentration(persons per sq. ft.) curve for school boys, experiment conducted in contrived situation for pedestrians flows in subways and on stairways in London shopping streets.

Oeding (1963), studied pedestrian flow with trip purpose and measured speed-flow relationship in Germany under mixed traffic condition.

Hoel (1968) has measured pedestrian travel rate in central business district and frequency distributions of walking speeds. In his study he analyzed the environmental factors which affects pedestrian motion such as time of day, external influence,environment.The difference between male and female pedestrians rates are also studied.

Older (1968) has studied pedestrian characteristics with detailed data on pedestrian in Britain shopping streets, while Navin and Wheeler(1969) have studied U.S.A university students. The study was done intending to represent the relationship between speed, density and flow of pedestrians walking.

Pedestrian Planning and Design – Fruin 1971, has given data of pedestrian flow including measurements on stairways and walkways, which describes and quantify the need of space to walk by people and to define individual comfort zones, developed the concept of the body ellipse. Also found that walking speed is directly proportional to the density and to be varying with respect to conditions and the Walking speed decline with age (After 65 years).

Henderson and Lyons (1972) and Polus et al. (1983) gave report on effects of gender on speed.Henderson 1971 measured speed distribution function for three crowd fluids, which was attributed to sexual in homogeneity. Henderson and Lyons 1972 observed the sexual difference in the human crowd motion under homogeneous traffic mix condition. Weidmann (1993) determined that under mixed traffic conditions pedestrian walking speed varies with density.

2.3 Literature Review on Different Pedestrian Dynamics Phenomena

Different diverse phenomena in walker elements which exists are lane formation or path development, zipper impact, motions at bi–directional bottlenecks, shock wave, and so forth.

Pushkarev and Zupan (1975),studied the capacity in walkways.Polus et al. (1983),studied and analyzed the different characteristics of pedestrians in the areas of sidewalks.He gave an effort to estimate the LOS definitions with respect to nature of flow (free flow, unstable flow, dense flow and jammed flow) for uniform width sidewalks and also observed that male pedestrians speed was far greater than female pedestrians speed, speed of pedestrians vary inversely with respect to density.

Gipps and Marksjo (1985) gave a model to show the interactions between pedestrians, this model was deliberated for graphical computer simulation.

Mori and Tsukaguchi (1987) found a new method for the evaluation of sidewalks with two different methods based on pedestrian opinion and behavior, by using the indices of pedestrian density and the width of the sidewalk level of service were also estimated.

Helbing (1991) presented the simulation on computers of the pedestrian motion which was expected to show certain types of regularities, explained through an algorithm for the individual

pedestrian behavior. This behavior of pedestrians determined by the intended walking speed, byseveral attractive and repulsive effects and by fluctuations. The pedestrian motion was based on decisions which was assumed for the optimization of pedestrian behavior and was explicitly modeled.Helbing et al. (2005) studied the alternate passing and stopping of pedestrians in counter flow.

Lam (2000) Investigated that due to the present situations pedestrians walk faster on outdoor walkways than of indoor walkways. Lam et al. (2003) have studied the effects of the bidirectional flow on pedestrian walking speed and flow at the indoor walkways of Hong Kong.

Helbing et al. (2005), performed experiments in bottleneck, corridors and in intersections, areas to study the self organizing behavior of pedestrian.

Blue and Adler (1999), presented pedestrian bi-directional motion through fundamental diagrams which was regulated by the use of cellular automata micro simulation method. Blue and Adler (2000), presented cellular automata micro simulation modeling of multidirectional pedestrian flow. In 2001 Blue and Adler, explains the use of Cellular automata micro simulation for the modeling bi directional pedestrian walkways, this modeling describes simulation three modes of bi-directional pedestrian flow i.e flows in directionally separated lanes, interspersed flow, and dynamic multi-lane (DML) flow.

Hoogendoorn and Daamen (2002), studied the pedestrian flow in transfer station. The modeling of pedestrian flow purposed as a simulation which was developed for estimation of mean walking times and its variability by transferring passengers and for visualizing walking patterns through transfer stations. This study with modeling aimed to know level of comfort for passengers in transfer stations. Hoogendoorn and Daamen (2003),for calibrating and validating

pedestrian flow models and for visualizing the pedestrian flows characteristics under a different conditions or circumstances, conducted controlled experiment in Delft University of Technology to study the effects of a experimental variables, which difficult to study inobservational research. Hoogendoorn and Daamen (2003), have studied pedestrian motion in bottleneck and explained the experimental results such as utilization of available space and capacity of the bottleneck. From experimental research Hoogendoorn and Daamen (2004), studied the self organizing behavior of pedestrian and formation of cluster and lane in two dimensional pedestrian flow. Hoogendoorn and Daamen (2005) studied the walking speed and behavior of pedestrians in bottlenecks with respect to capacity and also described the pedestrians microscopic behaviour inside bottleneck.Hoogendoorn and Daamen (2005) also explained the Zipper effect,which causes the limit of the bottleneck to increment in a stepwise manner with the width of the bottleneck.

Hoogendoorn and Daamen (2007), describes two dimensional pedestrian flow and flow-density relation by fundamental diagrams in oversaturated bottleneck.

Kretz et al. (2006),studied the conter flow of pedestrians inside 2meter width corridor with 67 no of passengers or pedestrians.

2.4 Literature Review on Cultural Difference

Morrall (1991),from his research studied the characteristics of pedestrian of the central business district of Colombo, Srilanka on sidewalks with different widths.Also found speed, density, flow and cultural differences between Calgary, Canada and other Asian studies. From the comparison the result indicated with respect to all groups of Asian pedestrian speed was slower than the observed speed in Calgary, Canada.

Tanaboriboon(1986) and (1991),compared the speed of Singapore, Bangkok pedestrians with American counterpart pedestrians. They conducted studies for speed determination in areas of walkways and sidewalks and examined the relation between pedestrian characteristics. Walk-in rates of pedestrians compared to the Western standards and with the results from the study of Asian countries. From the comparison, it was found that Asian pedestrian speed, lower compared to Western Counterparts.

Lam et al. (1995) gave a detailed study of pedestrian motion in Hong Kong to determine pedestrian characteristics walking distance, speed, flow and density on indoor and outdoor walkways. Pedestrian charecterstics relationships for different types of pedestrian construction or facilities were evaluated for indoor and outdoor walkways in Hong Kong. A comparison of the pedestrian characteristics between various international western cities was also shown. The collected data were intended for the use of design standards and simulation model in Hong Kong.

Seyfried et al.(2005),presented experimental results of laboratory conditions and discusses observations of the data samples shows a linear relation existing between the speed and the distance headway, which is regarded as the minimum required length for one pedestrian for

movement. A comparison between results of single-file motion with literature data smple for the movement through a plane.Seyfried et al.(2007),analyzed experimentally the unidirectional flow of pedestrian in bottlenecks with laboratory conditions, for the development of pedestrian characteristic speed, density and individual time gaps through the bottlenecks with different width is presented. The result of the study presented the linear growth flow with width.

Chattaraj et al.((2009) found the walking speed of pedestrian motion are different between two varying cultures that is Indian and German cultures by quantitative analysis. From the study Indian test persons found to be less influenced by the speed than German test persons. He also found the unorganized behavior of Indian persons which was considered to be more than those German persons.

Chattaraj et al.(2013) found the variation in the fundamental diagram of pedestrian flow for different cultures through modeling.From the study, it is shown that the Indian test persons speed is less dependent on density than the German test persons speed and also observed the more effectiveness of the unordered behavior of Indian test persons compared to the ordered behavior of German test persons. Without any statistical measure one cannot conclude about whether there are differences or not. Through hypothesis testing the results were compared and quantitatively observed that the differences exist between the fundamental diagrams of pedestrians due to the difference in the cultures.

2.2 Motivation:

From the literature review, it is noticed that several studies have done to understand pedestrian motion through experimental and field observations. The speed, density and flow characteristics and the existing interrelationship between them has been explained by fundamental diagrams from earlier studies. As human nature is vulnerable, so the pedestrian flow characteristics also vary depending upon various circumstances and factors. In the case of field observation the pedestrians found to walk freely according to their own ways of space requirement, where in experimental observation pedestrian flow was found to be under ideal conditions. Due to the difference between field and experimental studies the pedestrian flow characteristics must be varied. Yet there is no study have done to represent the changes occurring in parameters of pedestrian flow with respect to the experimental and field case, which motivated to represent the comparison of fundamental diagrams between field and experimental study.

2.3 Problem Statement

The problem related to this thesis is "to represent the comparison existing between fundamental diagrams of the field observation and experimental observation". The pedestrian motion with respect to age and gender and the variation of different pedestrian characteristics is particularly studied in field observation**.**

Chapter 3

Empirical observation: Experiment, Data collection and Data decoding

In literature review the pedestrian dynamics phenomena briefly described both in the application of empirical and practical studies with different regulatory factors. Through conducting well controlled laboratory experiments and practical field study the pedestrian dynamics intended to study in detail. As many factors affect pedestrian motion, there must be some discrepancies existing between the experimental and field study. For resolving these discrepancies,a series of laboratory experiments and field studies were conducted with respect to gender and gender mix. The experiments were conducted under ideal conditions, where interaction between pedestrians and overtaking are avoided. Three different types of lab experiment were carried out. The first experiment was conducted in N.I.T., Rourkela for the single file pedestrian notion of only male students of N.I.T, a second experiment was carried out for the single file pedestrian motion of alternate female and male students, and the third experiment was done by using only the female pedestrians of N. I. T. The experiment was followed to the same experimental setup used in the study of Chattaraj et.al 2009. (Age in between 20-26). The field study conducted in various locations with respect to gender, gender mix and age. Chapter 3 is divided into three sections. Chapter 3.1 is illustrated with the experimental study and field study. Section 3.2 yields the data collection procedure and the methodology followed in the study. Single file pedestrian movement in experimental observation and the field observations were done to understand the variation of speed, density, flow and distance headway for gender, gender mix and age. In section 3.3 the results from studies are presented.

3.1 Experiments

This section describes experimental and field study, which were designed for the development of the fundamental diagram. The laboratory experiments which conducted in N.I.T Rourkela campus are similar to the experiments which were conducted for the development of a fundamental diagram of the characteristics for German pedestrians in Seyfried et al. (2005) and Chattaraj et al. (2009). The shape and size, which are mentioned in Chattaraj et al. (2009) is adopted in this laboratory experiment. The corridor was set up with length lm =17. 3m and lp=2m framed with chairs and ropes, where entry and exit were demarcated with two ranging rods. Within this measured experimental section the three groups of different gender and gender mix single file pedestrian motion were studied.the different groups of pedestrians were asked to walk through the prepared corridor without overtaking, interaction and other disturbing actors.Rudimentary data recorded with the help of photographic procedure of video recording.

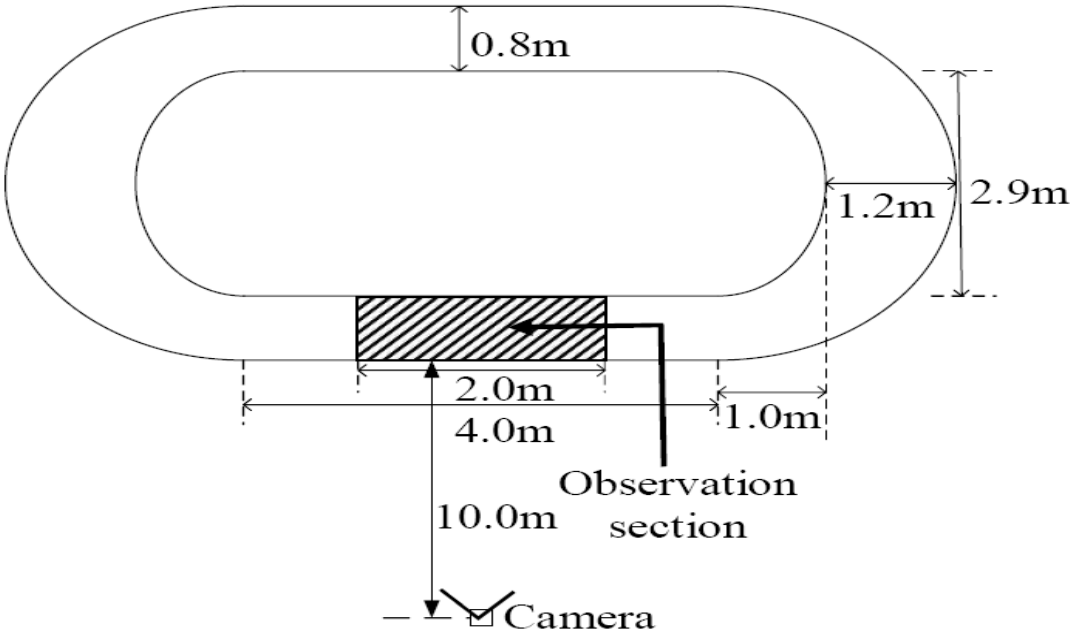

Fig 3.1 Experimental setup followed in the single file pedestrian experimental observation(Chattaraj et al. 2009)

Besides the experimental studies, a series of field studies have done at various locations. There are three procedures for the field study, which are

1. Site selection

2. Data collection,

3. Data decoding and analysis.

The data were collected with respect to age and gender.The primary aim of this data collection was to observe the variation occurring in pedestrian motion characteristics.Fundamental information recorded by a photographic method of feature recording with the open obliged length and width of the segment .Through the photographic system for recording the data,the manual counting of velocity can be easily done.To comprehend the pedestrian movement regarding gender, in four areas the information was gathered. Likewise regarding age, in two areas information were gathered.The length and width of the area where passerby movement happened were situated by site prerequisite.The video camera was set was situated with an available length from the considered area.Infield study area the pedestrian motion is unidirectional and bi-directional.The details of each field study are given in following tables.

Table 3.1 Data collected with respect to gender (above 18 age)

Location no	Place	Criteria	Length of the section	Width of the section
Location 1	CVR girls hostel	Only female	2.54 m	2.3 m
Location 2	SatishDhawan boys hostel	Only male	2.2m	1.7m
Location 3	LA hall	Mixed gender	2m	1.85m
Location 4	PadmanavEngg. College	Mixed gender	5.6m	2.4m

In the above listed locations,CVR girls hostel, SatishDhawanboys hostel, PadmanavEngg. College the pedestrian motion is bi-directional.InLA hall the field study,the pedestrian motion was partially controlled and uni-directional.

Table 3.2 Data collected with respect to age (below 18 age)

Location no	Place	Criteria	Length of the section	Width of the section
Location 1	Ispat English medium school	Boys and girls	3m	1.6m
Location 2	Carmel English medium school	Only girls	7.5m	6.4m

In the above listed all the locations,the pedestrian motion is bi-directional.

Fig. 3.2 Data collected in Satish Dhawan boys hostel Nit, Rkl to study only male pedestrian movement

Fig 3.3Data collected in C.V.R Girls Hostel Nit, Rkl to understand only female pedestrian motion

Fig. 3.4 Data collected in L.A hall Nit, Rkl to understand male-female pedestrian motion

Fig. 3.5 Data collected in PadmanavEngg. College, Rkl to understand male-female pedestrian motion

Fig. 3.6 Data collected in Ispat English medium school, Rkl to study boys-girls(school students under 18 age) pedestrian movement

Fig. 3.7 Data collected in Carmel English medium school, Rkl to understand only girls pedestrian motion

3.2 Data collection and Data decoding

Through the video recording the pedestrian movement is recorded. The entry and exit time for each pedestrians can be manually recorded from the video. In an experimental study the entry and exit were marked with the ranging rods,where as in field study the entry,exit and the outline of the section was marked properly with the chalk powder and tape.The difference between the entry and exit time gives the crossing time for each pedestrian.By acquiring the intersection time of every walker the speed rate can be computed.If Tin is the entry time and Tout is the exit time,where Lo is the total length of the section,then speed(Vp) can measured by the formula given below**.**

$$Vp=\frac{Lo}{T_{out}-T_{in}} \quad \text{.....eq(i)}$$

After Finding the speeds for each pedestrian, the flow per second is manually counted.Flow characterizes the quantity of passerby going in the watched or considered area every second. Speed, flow and density are interrelated with each other. By finding speed and flow,the density can be found out,From the equation of equilibrium given below

q=v.k……eq(ii)

Density is the no of pedestrians passing per unit length. If the density is denoted by k and $l_0$is the unit length and N_f is the no of pedestrians passing by,then density can be given by following equation

$$K=\frac{N_f}{l_0} \quad \text{.....eq(iii)}$$

The above three mentioned equations are adopted from Chattaraj et al. (2009).Flow is the no of pedestrians passing certain length in certain duration.by calculating speed and density,flow can be measured from the equilibrium equation shown above.

Chapter 4

Results and Discussions:

This chapter of this thesis represents the collected data analysis and show the acquired results obtained from the study. The first part of the result represents the fundamental relation between the pedestriandynamicsentities. The variation between the relationships of different pedestrian characteristics are studied through the fundamental diagrams.The primary focus is to study the speed-density,flow-density,speed-flow and distance headway-speed relationship for different gender and gender mix group under experimental and field observations.The second part of this section gives the comparison results obtained from the Hypothesis tests for different data sets.The comparison is done with different data sets with respect to age,gender and gender mix criteria.

4.1 Different fundamental diagrams for fieldobservations

4.1.1 The first location selected is the SatishDhawanboys hostel.

The study aimed at collecting photographic data for determining the different characteristics, if only male pedestrians.The first fundamental diagram is the speed-density relationship

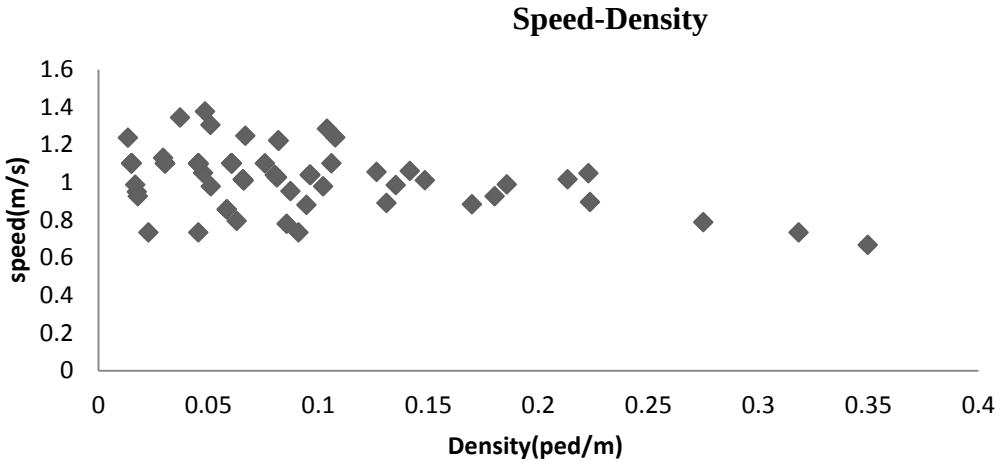

Fig. 4.1 Speed-Density plot for only male pedestrians

The above diagram shows when the density increases,the respective speed decreases.the speed-density has logarithemic and non-linear relationship.

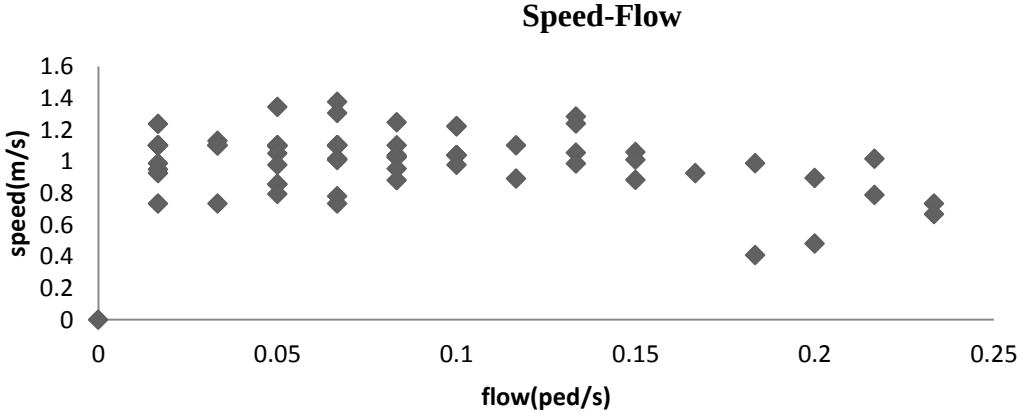

Fig. 4.2 Speed-Flow plot for only male pedestrians

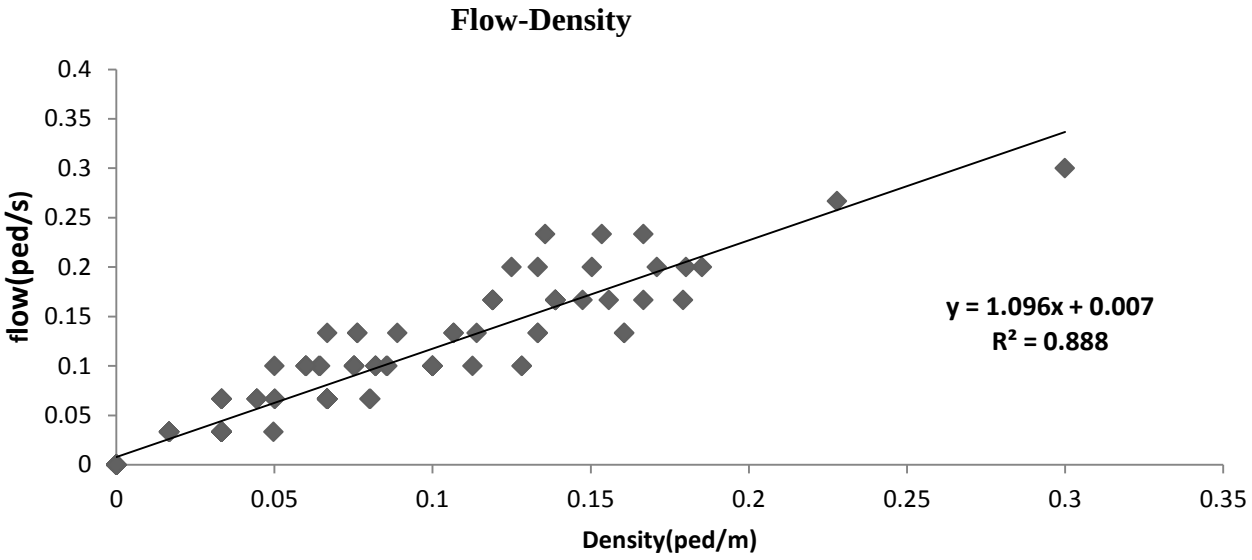

Fig. 4.3 Flow-Density plot for only male pedestrians

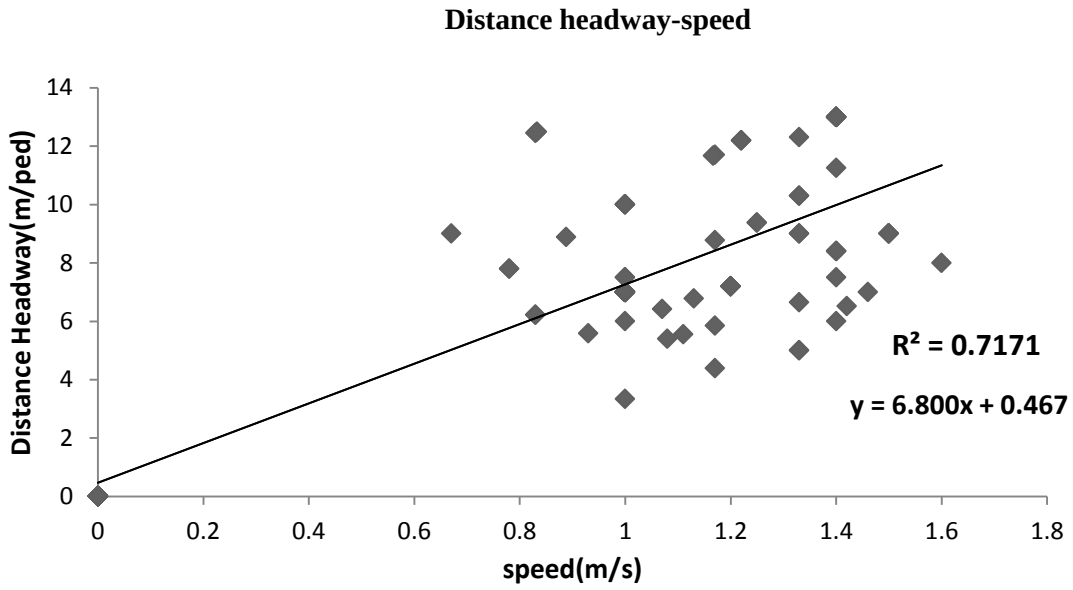

Fig. 4.4 Density Headway - Speed plot for only male pedestrians

4.1.2 Thesecond location which was selected for understanding only female pedestrians motion.The selected location was CV Raman girlshostel.The pedestrians age was above 18 years.

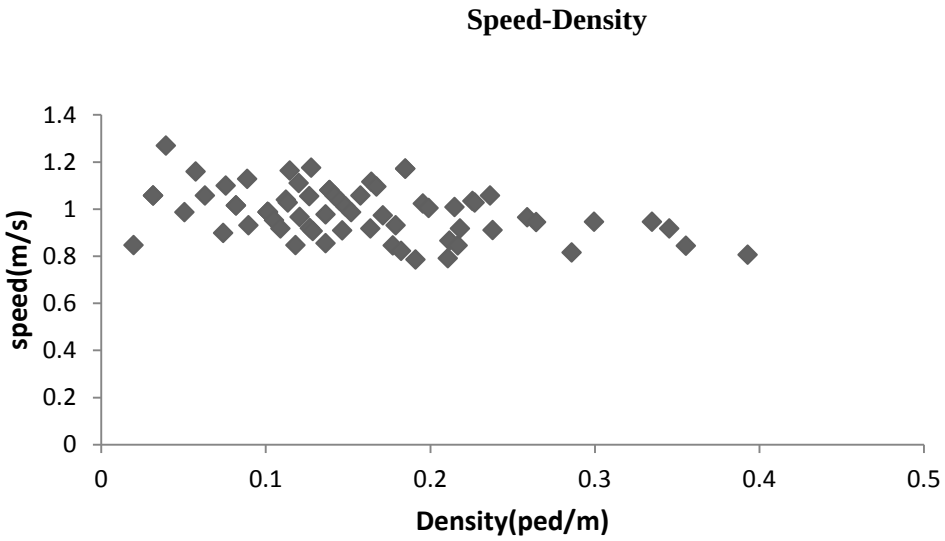

Fig. 4.5 Speed-Density plot for only female pedestrians

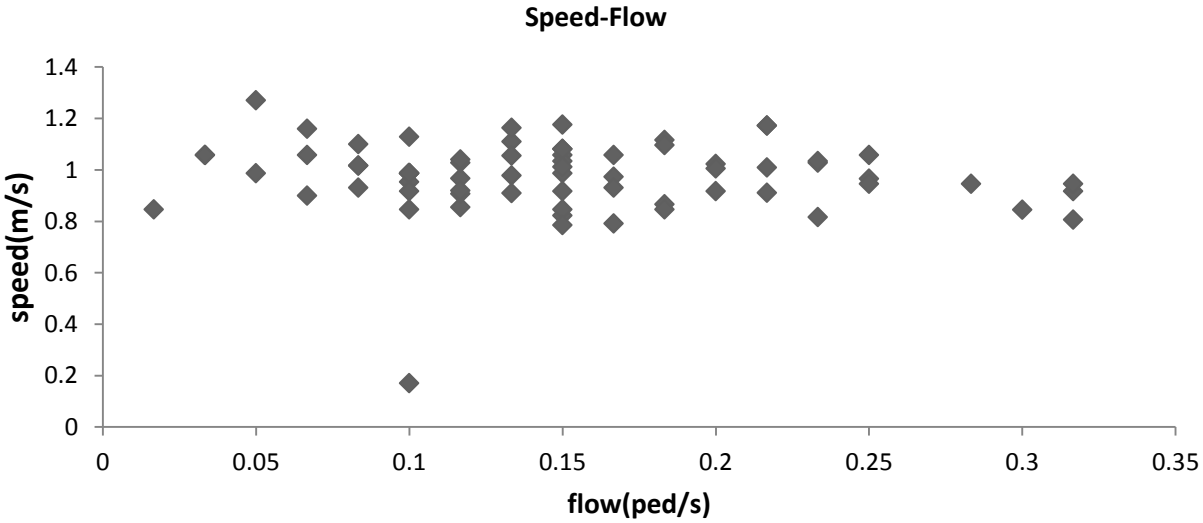

Fig. 4.6 Speed-Flow plot for only female pedestrians

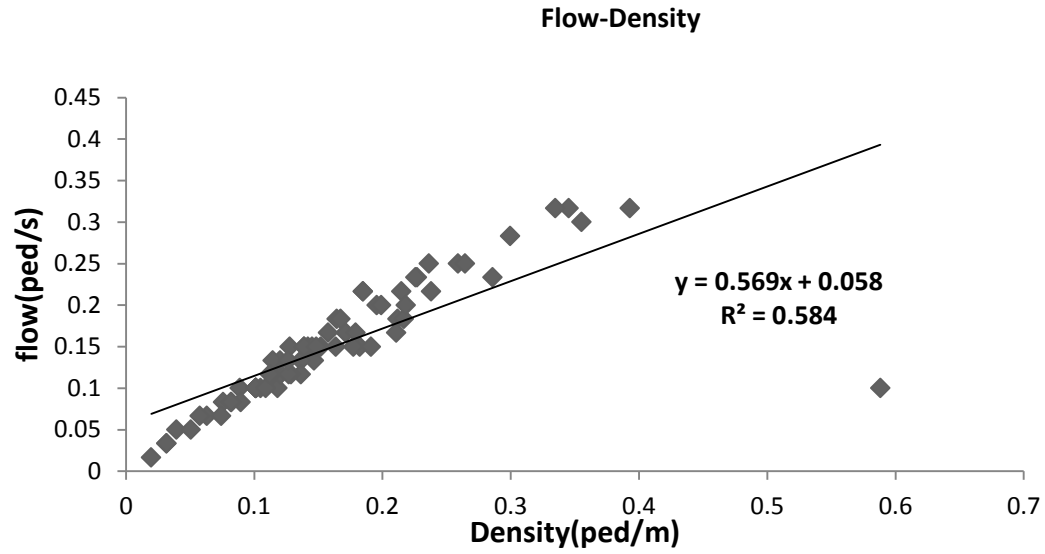

Fig. 4.7 Flow-Density plot for only female pedestrians

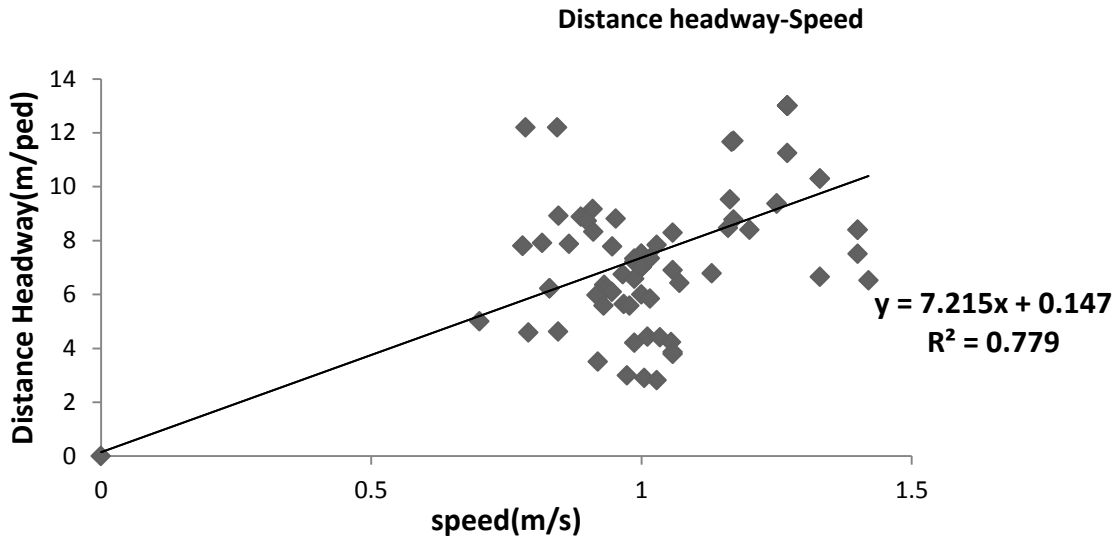

Fig. 4.8 Density Headway - Speed plot for only female pedestrians

4.1.3 The third field observation conducted in Lecturer Avenue Hall to study pedestrian motion for mixed gender case(age above 18).Followings are the fundamental diagram for mixed gender(LA Hall) .

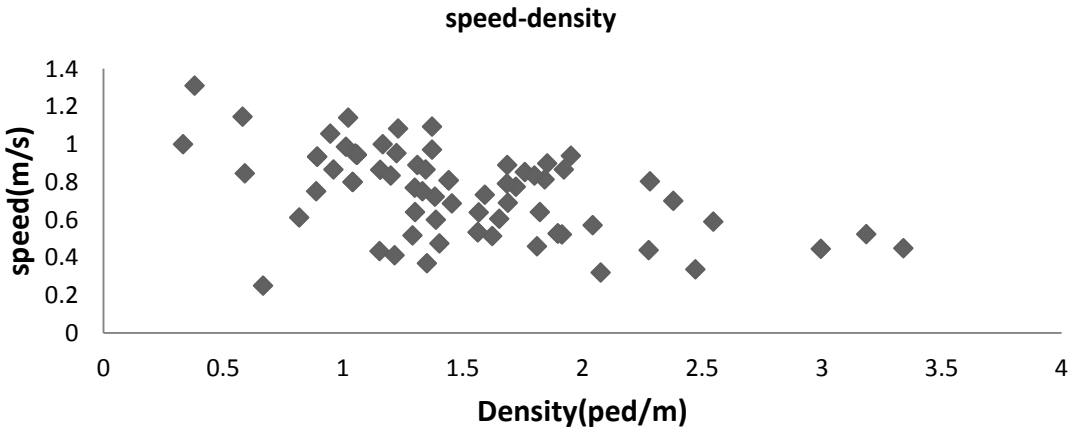

Fig. 4.9 Speed-Density plot for mixed gender

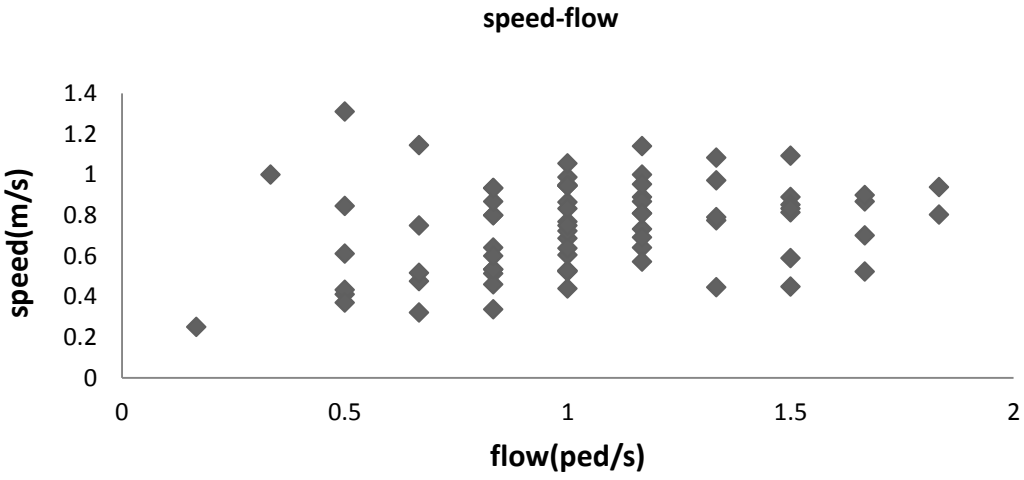

Fig. 4.10 Speed-Flow plot for mixed gender

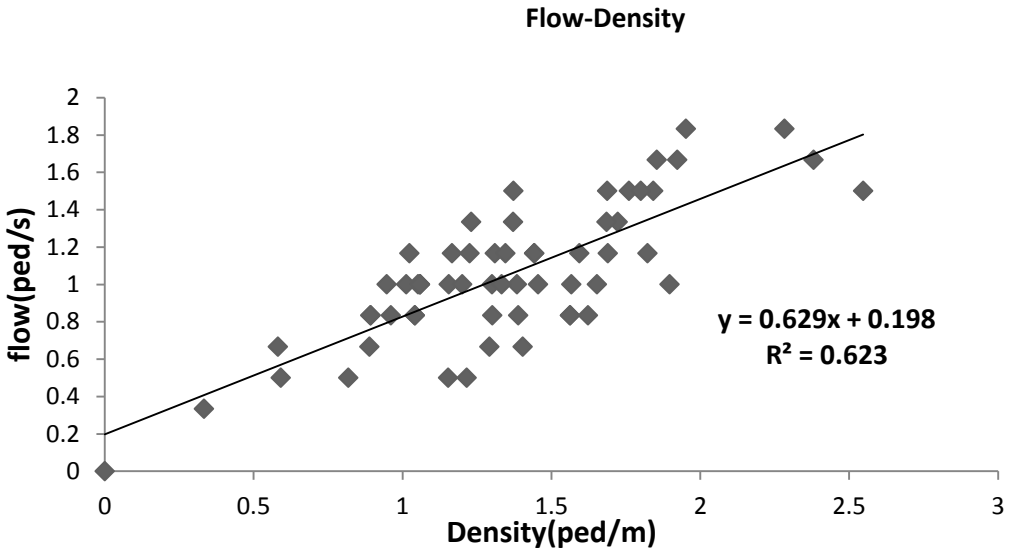

Fig. 4.11 Flow-Density plot for mixed gender

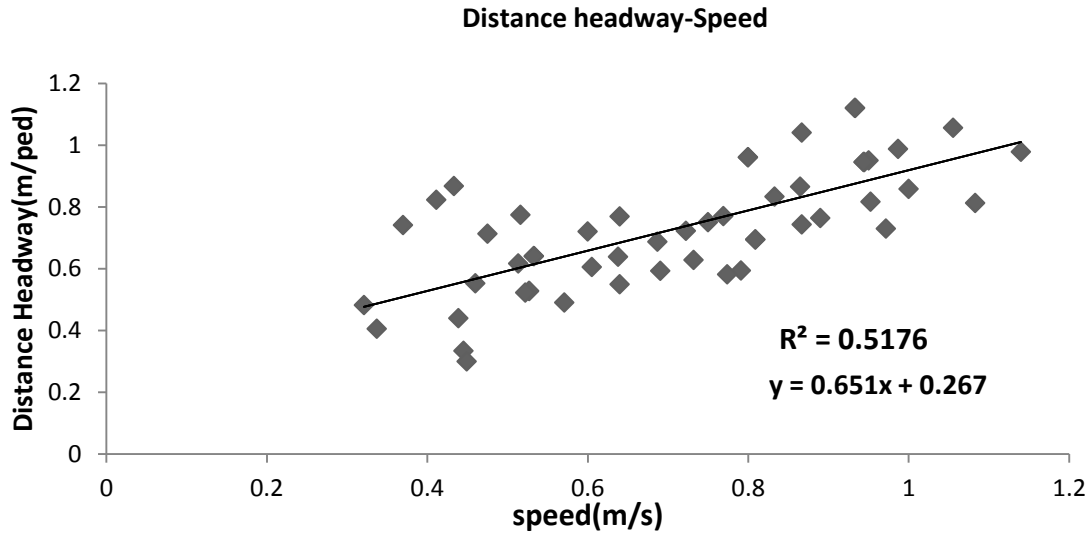

Fig. 4.12 Density Headway - Speed plot for mixed gender

4.1.4 The fourth location was PadmanavCollege.where the mixed gender(above age 18) pedestrian motion was studied.The fundamental diagram for mixed gender(Padmanav College)

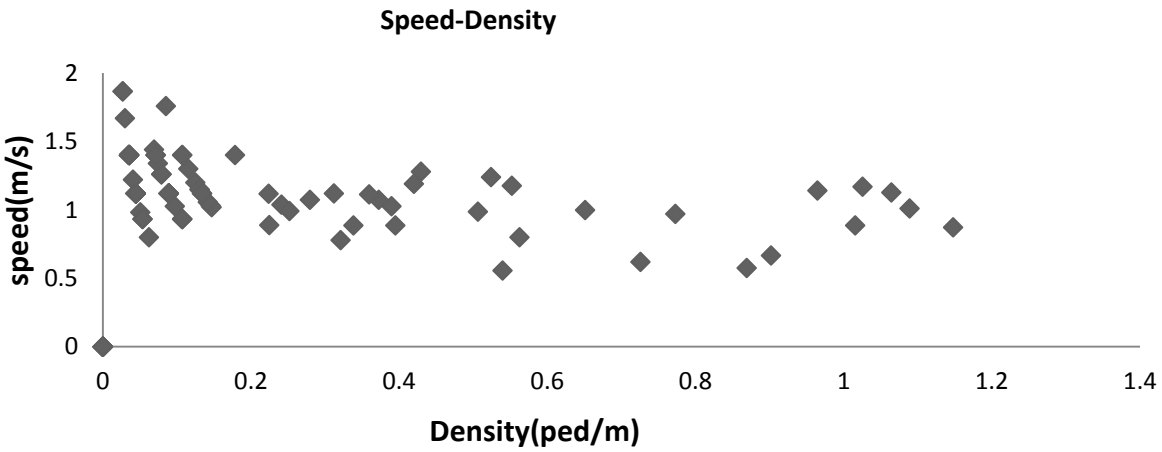

Fig. 4.13 Speed-Density plot for mixed gender

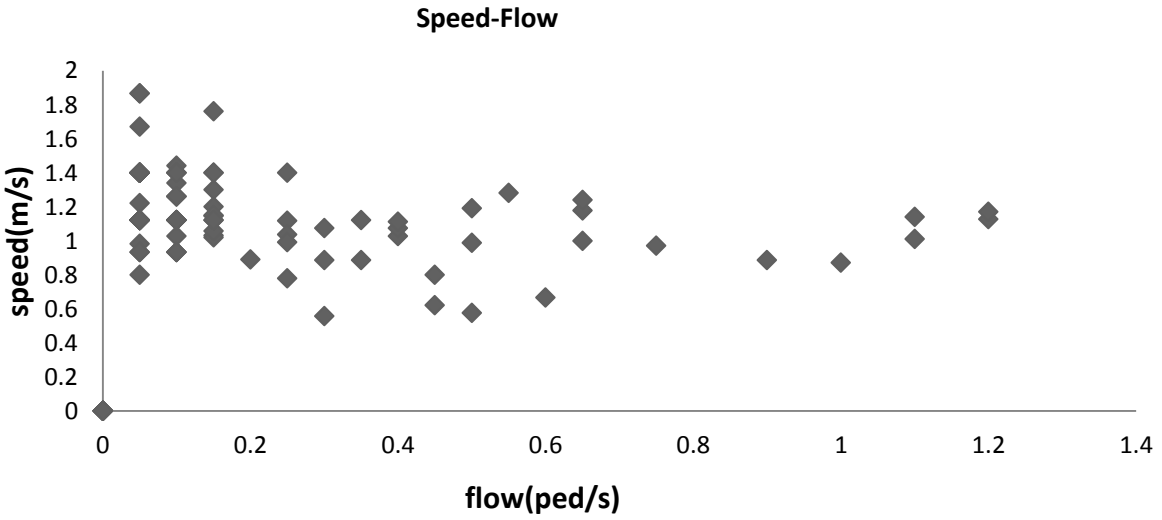

Fig. 4.14 Speed-Flow plot for mixed gender

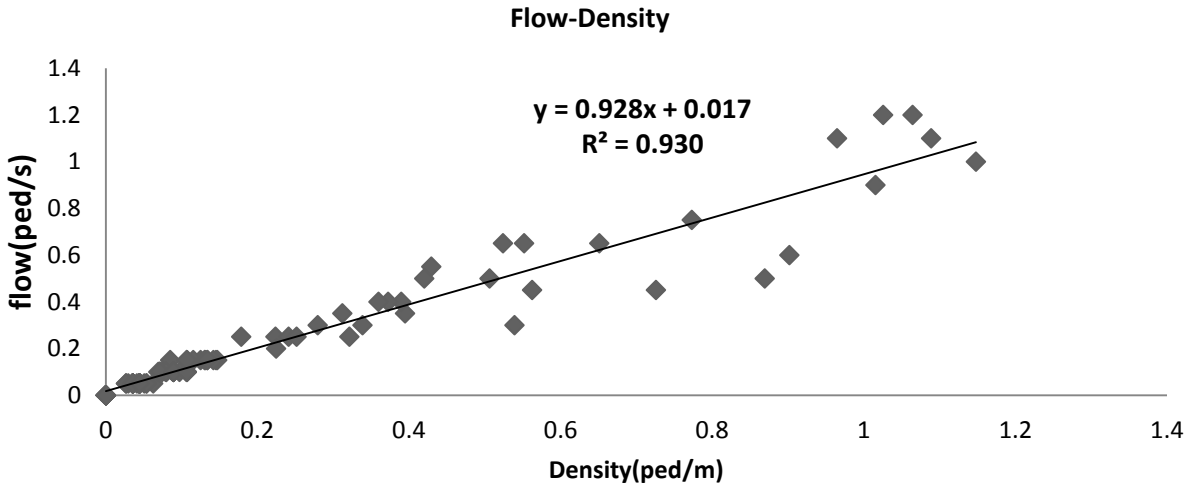

Fig. 4.15 Flow-Density plotfor mixed gender

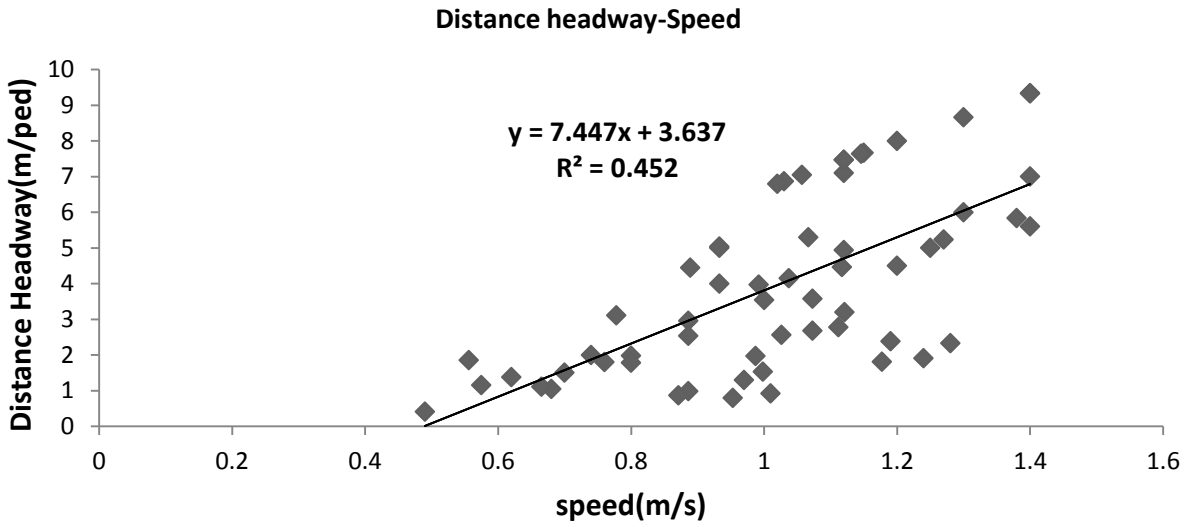

Fig. 4.16 Density Headway - Speed plot for mixed gender

4.1.5 The fifth study was conducted in Ispat English medium school,to study the mixed gender boys and girls(under age 18).The fundamental diagram for mixed gender school students(Ispat School) are shown below.

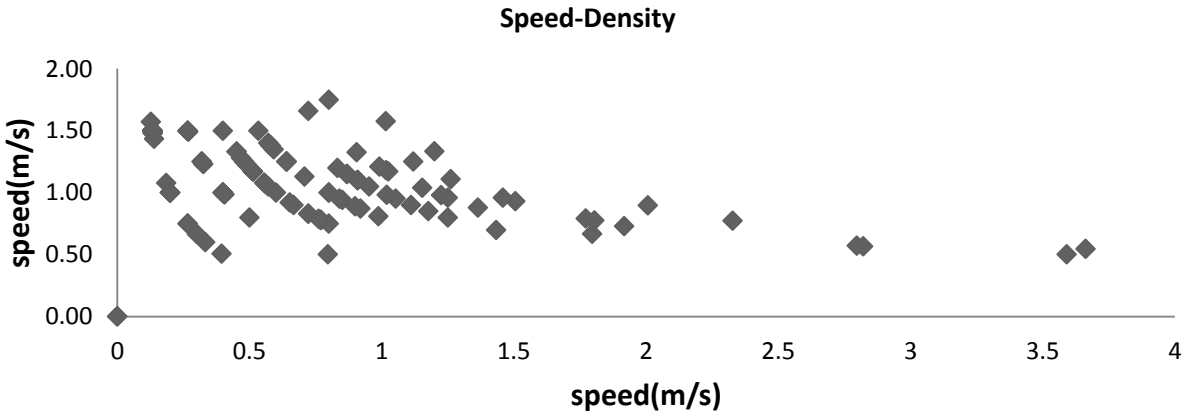

Fig. 4.17 Speed-Density plot for boys and girls pedestrians

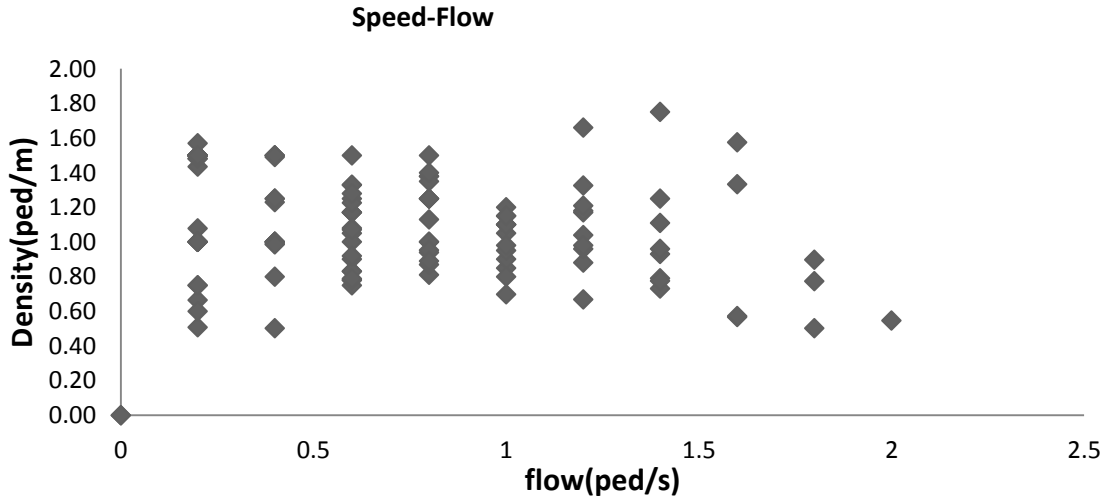

Fig. 4.18 Speed-Flow plot for boys and girls pedestrians

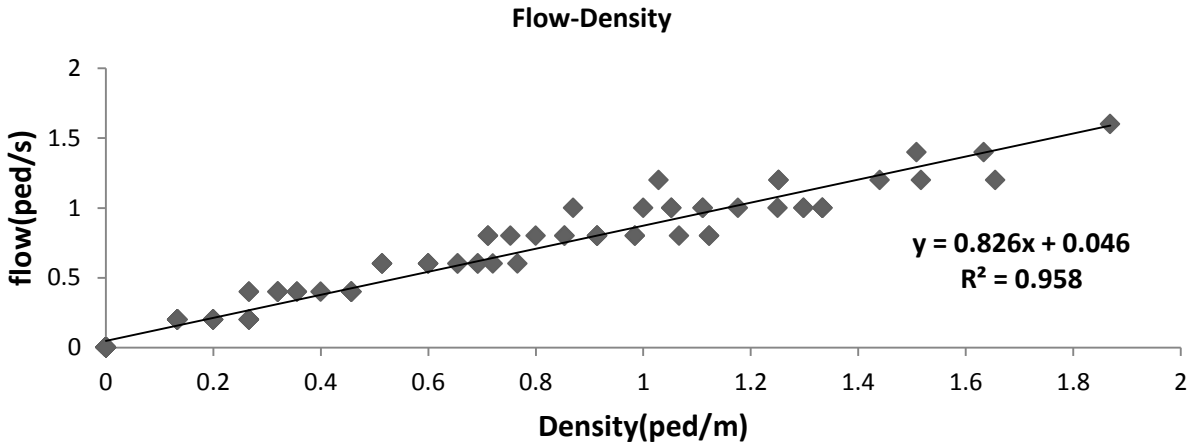

Fig. 4.19 Flow-Density plot for boys and girls pedestrians

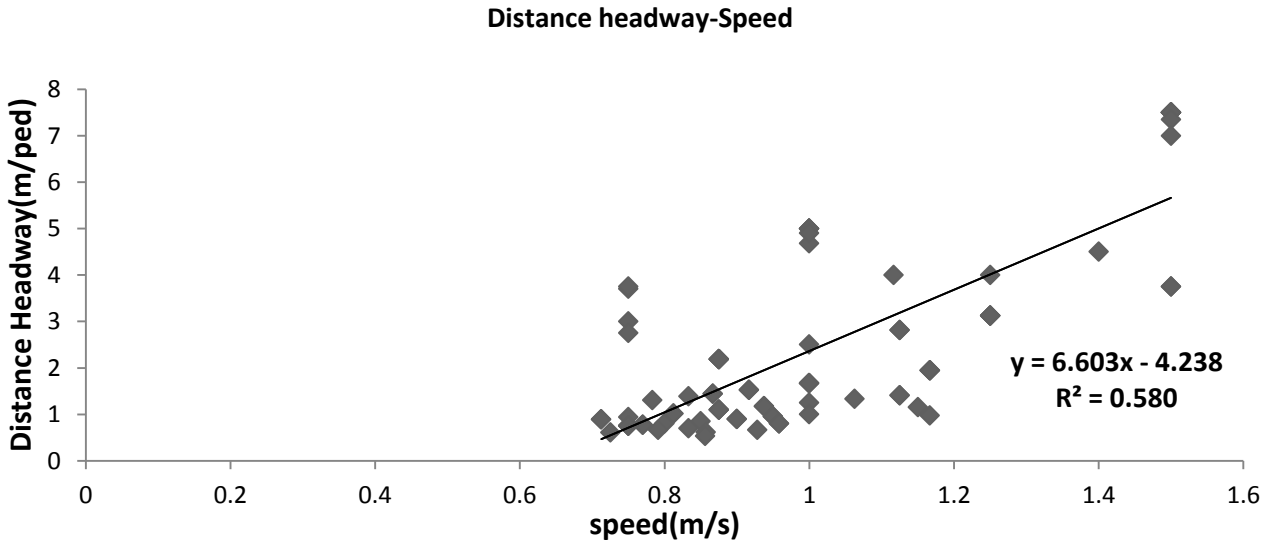

Fig. 4.20 Density Headway - Speed plot for boys and girls pedestrians

4.1.6 The sixth study was conducted in Carmel English medium school,to study the only girls(under age 18)pedestrians.The fundamental diagram for mixed gender school students(Ispat School) are shown below**.**The Fundamental diagram for girls school students(Carmel School) are presented below.

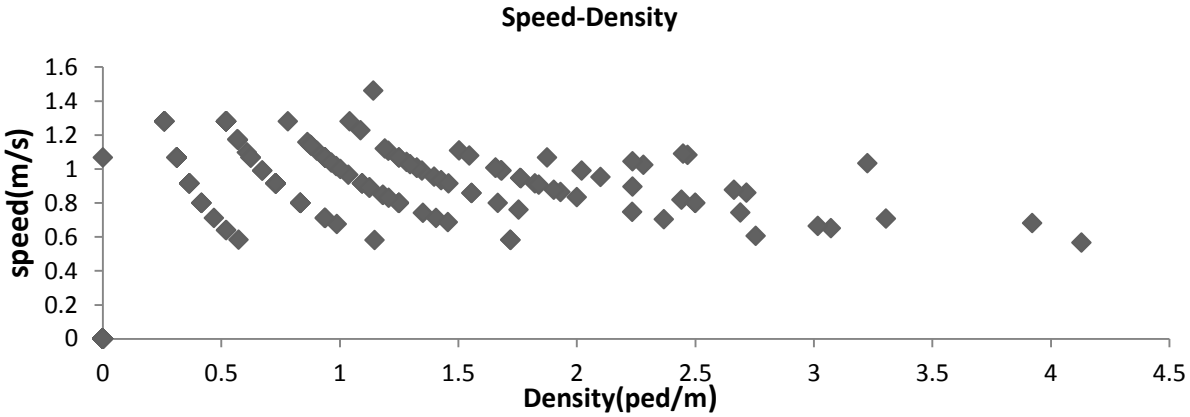

Fig. 4.21 Speed-Density plot for only girls pedestrians

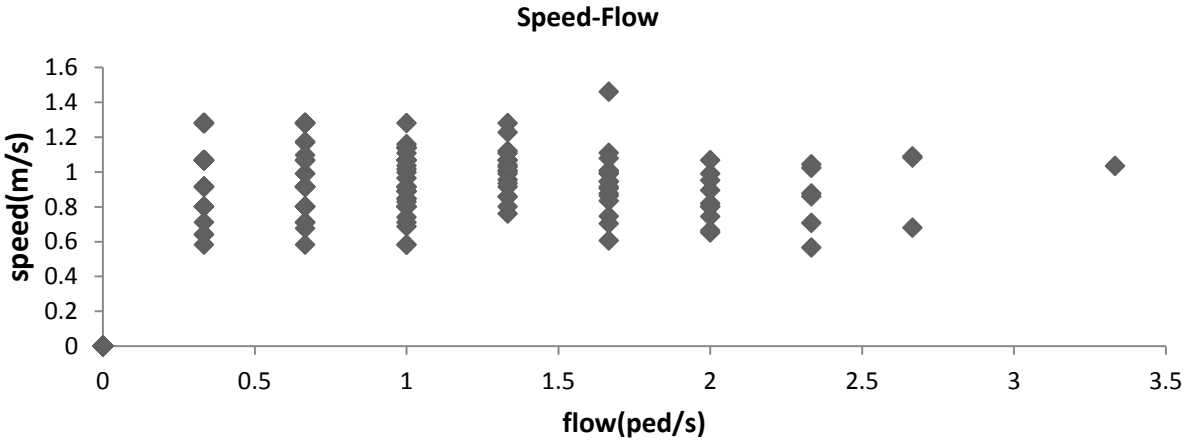

Fig. 4.22 Speed-Flow plot for only girls pedestrians

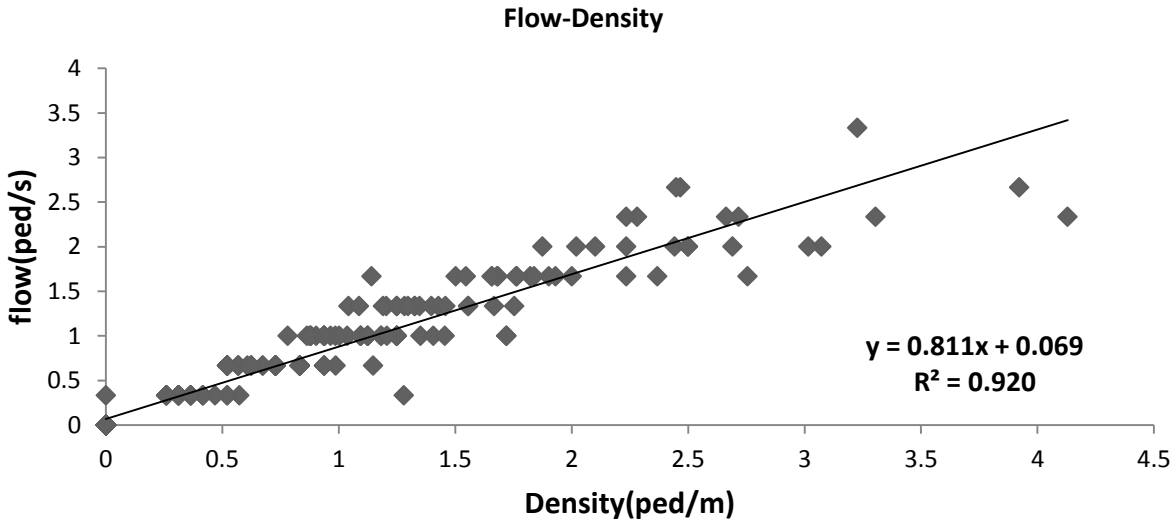

Fig. 4.23 Flow-Density plot for only girls pedestrians

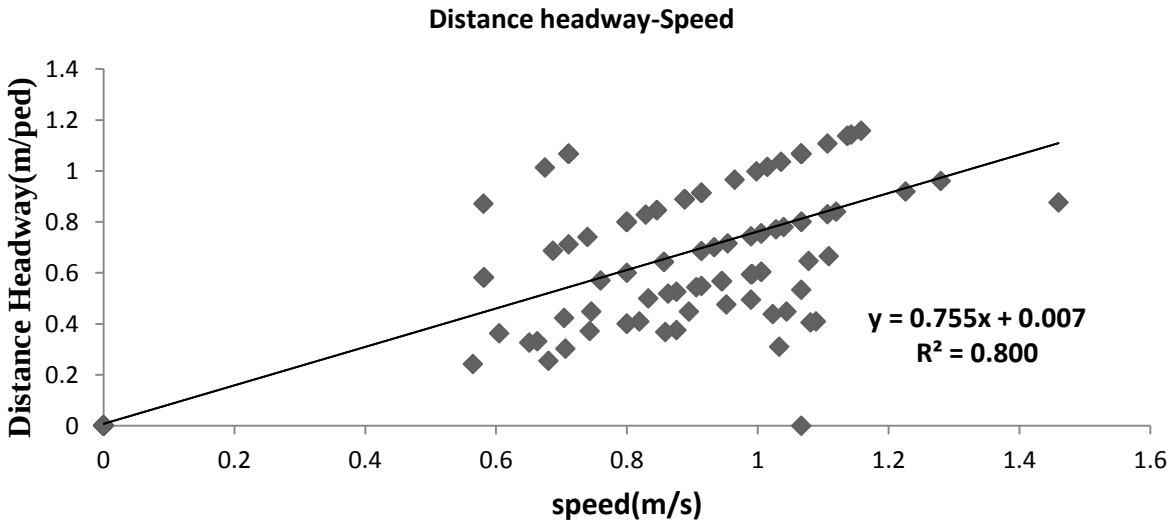

Fig. 4.24 Density Headway - Speed plot for only girls pedestrians

4.2.Representation of difference for different data sets by hypothesis test.

Hypothesis test is a statistical test to show the difference between different data sets. With respect to age, gender and gender mix criteria the statistical difference between experimental and field observations are shown here. The comparison between speed and distance headway observed in the field and experimental study is the primary aim of this section. The variation of speed and distance headway for both experimental study case and field study case are studied through the comparison.For obtaining the outcome,the P-value, significance level or alpha value,z critical and z observed from the hypothesis test are considered. From The z test is performed when the number of samples is more than 30 otherwise the t test is to be performed.As the no of samples in all the tests are more than 30, So we are performing z test.

4.2.1. Comparison for only male pedestrians (filled with experimental study)

The first comparison is done for only male speed(age is considered above 18).The first data set was taken from the study done in Satish Dhawan boys hostel and the second data was taken from the experimental study done in N.I.T campus for single file movement only for male pedestrians.

Table 4.1z-Test: Two Sample for Means for male pedestrian speed

	Variable 1	*Variable 2*
Mean	1.039857031	0.597620833
Known Variance	0.297	0.094314914
Observations	128	443
Hypothesized Mean Difference	0	
Z	8.786551024	
P(Z<=z) one-tail	0	
z Critical one-tail	1.644853627	
P(Z<=z) two-tail	0	
z Critical two-tail	1.959963985	

The second comparison is done for distance headway for only male pedestrians.The inverse of density gives distance head way**.**

Table 4.2z-Test: Two Sample for Means
for male pedestrian distance headway

	Variable 1	*Variable 2*
Mean	8.107601078	0.334911
Known Variance	8.493	0.01467
Observations	106	443
Hypothesized Mean Difference	0	
Z	4.491029006	
P(Z<=z) one-tail	0	
z Critical one-tail	1.281551566	
P(Z<=z) two-tail	0	
z Critical two-tail	1.959963985	

In the above two z test for speed and distance headway alpha value=0.05.The p value observed here is=0.The observed p value is less than alpha value,so we reject the null hypothesis.The two data sets for speed and distance headway between field and experimental study are considered to be different.As the p value is less than0.0001,so it is considered as extremely significant.

4.2.2. Comparison for only female pedestrians

This comparion section is divided in three sub sections.The first section shows the comparison between feild to experimental study.(CVR girls hostel and single file experimental study in N.I.T campus,in both the case age above 18).The second sub section represents the comparison between field to field study i.eCVR girls hoste(age considered above 18), where the another field study was done in Carmel girls schoolcampus,Rourkela for only girls pedestrians(age below 18).The third subsection shows the comparison between field to experimental study(Carmel girls high school,where age of school girls pedestrian under 18 andsingle file experimental study in N.I.T campus for female age above 18).

Comparison between feild to experimental study(CVR girls hostel and single file experimental study in N.I.T campus).

The comparison of speed between above two fields and experimental studies shown below

Table 4.3z-Test: Two Sample for Means for female pedestrian speed

	Variable 1	*Variable 2*
Mean	0.976854422	0.582293385
Known Variance	0.069538688	0.094207715
Observations	636	348
Hypothesized Mean Difference	0	
z	20.23923902	
P(Z<=z) one-tail	0	
z Critical one-tail	1.644853627	
P(Z<=z) two-tail	0	
z Critical two-tail	1.959963985	

The second comparison is for distance headway for only female pedestrians

Table 4.4z-Test: Two Sample for Means for female pedestrian distance headway

	Variable 1	*Variable 2*
Mean	5.880912289	0.344093
Known Variance	8.898751863	0.108538
Observations	70	378
Hypothesized Mean Difference	0	
z	15.51154068	
P(Z<=z) one-tail	0	
z Critical one-tail	1.644853627	
P(Z<=z) two-tail	0	
z Critical two-tail	1.959963985	

In the above two z test for speed and distance headway alpha value=0.05.The p value observed here is=0.The observed p value is less than alpha value,so we reject the null hypothesis.The two data sets for speed and distance headway between field and experimental study are considered to be different.As the p value is less than0.0001,so it is considered as extremely significant.

4.2.3Comparison between field to field study i.e CVR girls hostel(age considered above 18), where the another field study was done in Carmel girls school campus,Rourkela for only girls pedestrians(age below 18).

The comparison is for speed for only female and girls pedestrians given below

Table 4.5z-Test: Two Sample for Means for female and girls pedestrians speed

	Variable 1	*Variable 2*
Mean	0.976854422	0.939097214
Known Variance	0.069538688	0.094207715
Observations	636	348
Hypothesized Mean Difference	0	
Z	2.6888084	
P(Z<=z) one-tail	0.003585378	
z Critical one-tail	1.644853627	
P(Z<=z) two-tail	0.007170756	
z Critical two-tail	1.959963985	

In the above two z test for speed alpha value=0.05.The p value observed here is=0.007170756.The observed p value is less than alpha value,so we reject the null hypothesis.The two data sets for speed between field and feild study are considered to be different.As the p value is less than0.01,so it is considered as significant

The second comparison is for distance headway for only female and girls pedestrians.

Table 4.6 z-Test: Two Sample for Means for female and girls pedestrians distance headway

	Variable 1	*Variable 2*
Mean	8.880912289	0.805843
Known Variance	8.898751863	0.108538
Observations	70	378
Hypothesized Mean Difference	0	
Z	8.798449506	
P(Z<=z) one-tail	0	
z Critical one-tail	1.644853627	
P(Z<=z) two-tail	0	
z Critical two-tail	1.959963985	

In the above two z test for distance headway alpha value=0.05.The p value observed here is=0.The observed p value is less than alpha value,so we reject the null hypothesis.The two data sets for speed and distance headway between field and experimental study are considered to be different.As the p value is less than0.0001,so it is considered as extremely significant.

4.2.4 Comparison between field to experimental study(Carmel girls high school,where age of school girls pedestrian under 18 and single file experimental study in N.I.T campus for female age above 18),

The comparison is for speed for only female and girls pedestrians given below

Table 4.7z-Test: Two Sample for Means for girls and female pedestrian speed

	Variable 1	*Variable 2*
Mean	0.939097214	0.582293385
Known Variance	0.043398015	0.094207715
Observations	494	348
Hypothesized Mean Difference	0	
Z	18.84288253	
P(Z<=z) one-tail	0	
z Critical one-tail	1.644853627	
P(Z<=z) two-tail	0	
z Critical two-tail	1.959963985	

In the above two z test for speed alpha value=0. 05. The p value observed here is=0. The observed p value is less than alpha value,so we reject the null hypothesis.The two data sets for speed and distance headway between field and experimental study are considered to be different.As the p value is less than0.0001,so it is considered as extremely significant

The second comparison is for distance headway for only female and girls pedestrians

Table 4.8z-Test: Two Sample for Means for girls and female pedestrian distance headway

	Variable 1	*Variable 2*
Mean	0.805843139	0.34409256
Known Variance	.85449011	0.10853826
Observations	232	378
Hypothesized Mean Difference	0	
Z	2.362687889	
P(Z<=z) one-tail	0.009071471	
z Critical one-tail	1.644853627	
P(Z<=z) two-tail	0.018142942	
z Critical two-tail	1.959963985	

In the above two z test for distance headway alpha value=0.05.The p value observed here is=0.018142942.The observed p value is less than alpha value,so we reject the null hypothesis.The two data sets for speed and distance headway between field and experimental study are considered to be different. As the p value is less than0.05,so it is considered as marginally significant

4.2.5 Comparison of mixed gender pedestrian group:

For the comparison of mixed gender group the data collected in four locations Lecturer Avenue hall,PadmanavEngg.College,Ispat English medium school and the experimental study in N.I.T campus for single file male and female pedestrians.The pedestrians participated in the Lecturer Avenue hall, PadmanavEngg. College were of age above 18. ,where the in Ispat English medium school,the study was done for school boys and girls students of age under 18.The comparison is done with respect to gender mix and age.This comparison part is divided in to three sub parts.The first represents the comparison between field to field study i.e Lecturer Avenue hall and PadmanavEngg. College(age of pedestrians in both of the field studies.The second subpart represents the comparison between field and experimental studies ,which is subdivided in to two parts.The first part represents the comparison between Lecturer Avenue hall and Experimental study.The second part represents the comparison between PadmanavEngg. College and the experimental study.The third subpart is divided into two sections.The first section shows the comparison between field(Ispat English Medium school where age below 18) to field study(Lecturer Avenue hall,PadmanavEngg. College,age above 18).The second section shows the comparison between field(Ispat English Medium school where age below 18) and experimental study(age above 18).

4.2.6 Comparison between field to field study i.e Lecturer Avenue hall and PadmanavEngg. College(age of pedestrians in both of the field studies is above 18)

The comparison of speed between above two field studies shown below

Table 4.9z-Test: Two Sample for Means for mixed gender speed

	Variable 1	*Variable 2*
Mean	0.746616462	1.11006383
Known Variance	0.077073806	0.061
Observations	452	300
Hypothesized Mean Difference	0	
Z	-1.938978967	
P(Z<=z) one-tail	0.02625195	
z Critical one-tail	1.644853627	
P(Z<=z) two-tail	0.052503899	
z Critical two-tail	1.959963985	

In the above two z test for speed alpha value=0.05.The p value observed here is=0.053503899.The observed p value is greater than alpha value,so we accept the null hypothesis.The two data sets for speed between field and experimental study are considered to be same.As the p value is less than0.10,so it is considered as not significant

The comparison of distance headway between above two field studies shown below

Table 4.10z-Test: Two Sample for Means mixed gender distance headway

	19.64	*1.692*
Mean	10.37832554	0.790166426
Known Variance	9.05269	0.19
Observations	92	71
Hypothesized Mean Difference	0	
Z	9.22904908	
P(Z<=z) one-tail	0	
z Critical one-tail	1.644853627	
P(Z<=z) two-tail	0	
z Critical two-tail	1.959963985	

In the above two z test for distance headway alpha value=0.05.The p value observed here is=0.The observed p value is less than alpha value,so we reject the null hypothesis.The two data sets for speed and distance headway between field and experimental study are considered to be different.As the p value is less than0.0001,so it is considered as extremely significant

4.2.7 Comparison between field and experimental studies

(i) **Comparison between Lecturer Avenue hall and Experimental study**.

The comparison of speed between above two field studies shown below

Table 4.11 z-Test: Two Sample for Means mixed gender speed

	Variable 1	*Variable 2*
Mean	0.745256752	0.597621
Known Variance	0.077073806	0.094315
Observations	357	443
Hypothesized Mean Difference	0	
Z	2.980387484	
P(Z<=z) one-tail	0.00143942	
z Critical one-tail	1.644853627	
P(Z<=z) two-tail	0.00287884	
z Critical two-tail	1.959963985	

In the above two z test for distance headway alpha value=0.05.The p value observed here is=0.00287884.The observed p value is less than alpha value,so we reject the null hypothesis.The two data sets for speed between field and experimental study are considered to be different.As the p value is less than0.01,so it is considered as significant.

The comparison of distance headway between above two field studies shown below.

Table 4.12 z-Test: Two Sample for Means for mixed gender distance headway

	Variable 1	*Variable 2*
Mean	0.802691892	0.337555694
Known Variance	0.196243415	0.012623061
Observations	72	447
Hypothesized Mean Difference	0	
Z	8.863609001	
P(Z<=z) one-tail	0	
z Critical one-tail	1.644853627	
P(Z<=z) two-tail	0	
z Critical two-tail	1.959963985	

In the above two z test for distance headway alpha value=0.05.The p value observed here is=0.The observed p value is less than alpha value,so we reject the null hypothesis.The two data sets for speed and distance headway between field and experimental study are considered to be different.As the p value is less than0.0001,so it is considered as extremely significant

(ii) Comparison between PadmanavEngg. College and the experimental study

The comparison of speed between above two field studies shown below

Table 4.13 z-Test: Two Sample for Means
mixed gender speed

	Variable 1	*Variable 2*
Mean	1.11006383	0.746616
Known Variance	0.0618	0.094315
Observations	300	452
Hypothesized Mean Difference	0	
Z	8.734550158	
P(Z<=z) one-tail	0	
z Critical one-tail	1.644853627	
P(Z<=z) two-tail	0	
z Critical two-tail	1.959963985	

In the above two z test for speed alpha value=0.05.The p value observed here is=0.The observed p value is less than alpha value,so we reject the null hypothesis.The two data sets for speed and distance headway between field and experimental study are considered to be different.As the p value is less than0.0001,so it is considered as extremely significant

The comparison of distance headway between above field and studies shown below

Table 4.14 z-Test: Two Sample for Means for mixed gender distance headway

	Variable 1	*Variable 2*
Mean	10.47791344	0.337555694
Known Variance	9.05269	0.012623061
Observations	93	447
Hypothesized Mean Difference	0	
Z	9.825526934	
P(Z<=z) one-tail	0	
z Critical one-tail	1.644853627	
P(Z<=z) two-tail	0	
z Critical two-tail	1.959963985	

In the above two z test for distance headway alpha value=0.05.The p value observed here is=0.The observed p value is less than alpha value,so we reject the null hypothesis.The two data sets for speed and distance headway between field and experimental study are considered to be different.As the p value is less than0.0001,so it is considered as extremely significant

4.2.8 (i) Comparison between field (Ispat English Medium school where age below 18) to field study(Lecturer Avenue hall)

The comparison of speed between above two field studies shown below

Table 4.15 z-Test: Two Sample for Meansboys,girls and mixed gender speed

	Variable 1	*Variable 2*
Mean	0.93151751	0.746616
Known Variance	0.04814886	0.077074
Observations	257	452
Hypothesized Mean Difference	0	
Z	-1.92347872	
P(Z<=z) one-tail	0.027209978	
z Critical one-tail	1.281551566	
P(Z<=z) two-tail	0.054419956	
z Critical two-tail	1.644853627	

In the above two z test for speed alpha value=0.05.The p value observed here is=0. The p value observed here is=0.054419956.The observed p value is greater than alpha value,so we accept the null hypothesis.The two data sets for speed between two field studies are considered to be same.As the p value is less than0.10,so it is considered as not significant.

The comparison of distance headway between above two field studies shown below

Table 4.16 z-Test: Two Sample for Means for boys,girls and mixed gender distance headway

	Variable 1	*Variable 2*
Mean	0.802691892	1.790000865
Known Variance	12.42758416	.196243
Observations	72	106
Hypothesized Mean Difference	0	
Z	9.77414086	
P(Z<=z) one-tail	0	
z Critical one-tail	1.644853627	
P(Z<=z) two-tail	0	
z Critical two-tail	1.959963985	

In the above two z test for speed alpha value=0.05. The observed p value is less than alpha value,so we reject the null hypothesis.The two data sets for distance headway between field and experimental study are considered to be different.As the p value is less than0.0001,so it is considered as extremely significant

(ii)comparison between field(Ispat English Medium school where age below 18) to field study(PadmanavEngg. College,age above 18)

The comparison of speed between above two field studies shown below

Table 4.17 z-Test: Two Sample forMeansboys,girls and mixed gender speed

	Variable 1	*Variable 2*
Mean	0.93151751	1.11006383
Known Variance	.048	0.061822802
Observations	257	300
Hypothesized Mean Difference	0	
z	-1.2993137	
P(Z<=z) one-tail	0.096918135	
z Critical one-tail	1.281551566	
P(Z<=z) two-tail	0.093836271	
z Critical two-tail	1.644853627	

In the above two z test for speed alpha value=0.05.The p value observed here =.093836271.The observed p value is greater than alpha value,so we accept the null hypothesis.The two data sets for speed betweentwo field studies are considered to be same.As the p value is less than0.10,so it is considered as not significant.

The comparison of distance headway between above two field studies shown below

Table 4.18 z-Test: Two Sample for Means for boys,girls and mixed gender distance headway

	Variable 1	*Variable 2*
Mean	10.47791344	1.790001
Known Variance	12.42758416	9.05269
Observations	93	106
Hypothesized Mean Difference	0	
z	3.690825285	
P(Z<=z) one-tail	0	
z Critical one-tail	1.644853627	
P(Z<=z) two-tail	0	
z Critical two-tail	1.959963985	

In the above two z test for distance headway alpha value=0.05.The p value observed here is=0.The observed p value is less than alpha value,so we reject the null hypothesis.The two data sets for speed and distance headway between field and experimental study are considered to be different.As the p value is less than0.0001,so it is considered as extremely significant

4.2.9 comparison between field(Ispat English Medium school where age below 18) and experimental study(age above 18).

The comparison of speed between above two field studies shown below

Table 4.19 z-Test: Two Sample for Means for boys,girls and mixed gender speed

	Variable 1	*Variable 2*
Mean	0.941245136	0.746616462
Known Variance	0.048	.094
Observations	257	452
Hypothesized Mean Difference	0	
Z	9.881900846	
P(Z<=z) one-tail	0	
z Critical one-tail	1.281551566	
P(Z<=z) two-tail	0	
z Critical two-tail	1.644853627	

In the above two z test for speed alpha value=0.05.The p value observed here is=0.The observed p value is less than alpha value,so we reject the null hypothesis.The two data sets for speed and distance headway between field and experimental study are considered to be different.As the p value is less than0.0001,so it is considered as extremely significant

The comparison of distance headway between above two field studies shown below

Table 4.20 z-Test: Two Sample for Means for boys,girls and mixed gender distance headway

	Variable 1	*Variable 2*
Mean	1.790000865	0.337555694
Known Variance	12.4275	0.01262306
Observations	106	447
Hypothesized Mean Difference	0	
Z	12.51466104	
P(Z<=z) one-tail	0	
z Critical one-tail	1.644853627	
P(Z<=z) two-tail	0	
z Critical two-tail	1.959963985	

In the above two z test for speed alpha value=0.05.The p value observed here is=0.The observed p value is less than alpha value,so we reject the null hypothesis.The two data sets for speed and distance headway between field and experimental study are considered to be different.As the p value is less than0.0001,so it is considered as extremely significant

Chapter-5

Summary and Conclusions

5.1 Summary

This study was conducted to visualize the difference between experimental and field study. The experimental study was done earlier with respect to gender and gendermix condition (N.I.T., Rourkela) with different pedestrians group for single file movement. Several numbers of field study in different locations have done with respect to age, gender and mixed gender criteria in this study. Speed, density and flow were manually calculated and the relationship between different pedestrian's characteristics is established for each field study through fundamental diagram.The difference which is existing between the field and experimental study are evaluated by statically hypothesis testing with respect to age, gender and mixed gender. The significance of each comparison is shown.

5.2 Conclusions

In thisresearch, comparisons between experimental and different field observations for speed and distance headway were done with respect to age, gender and mixed gender conditions. The comparison for speed and distance headway for only male pedestrians between field (Satish Dhawan boys hostel) and experimental study(N.I.T campus) were found to be extremely significant.The comparison for speed and distance headway for only female pedestrians between field (CVR girls hostel) and experimental study(N.I.T campus,single file only male pedestrians motion) were found to be extremely significant.With respect to age the comparison done field(CVR girls hostel) to field(Carmel English medium school).For speed the difference was found to be significant for distance headway difference was found to be extremely significant.With respect to age the field(Carmel English medium school) to experimental study(N.I.T campus,single file only female pedestrians motion).It is found from the hypothesis that for speed the difference is marginal significant and for distance head way the difference was found to be extremely significant. The next hypothesis test was done for mixed gender case and age in between two field and experimental studies.The first comparison is done between field(Lecturer Avenue hall) to field study(PadmanavEngg college) with considered age more than 18.For the above case speed was found to be same and not significant.The difference between distance headway was found to be extremely significant.The second comparison was done betweenfield(Lecturer Avenue Hall) and experimentalstudy(N.I.T campus,single file mixed gender motion).The speed Difference is found to besignificant and the difference between distance headwat found to be extremely significant.The second comparison was done between field(Padmanavengg. College) and experimentalstudy(N.I.T campus,single file mixed gender motion). The speed difference and distance headway difference was found to be extremely

significant.With respect to age the comparision is done with three cases.The first comparison betweenfield(Ispat English medium school,pedestrian age below 18) to field study(Lecturer Avenue Hall,pedestrians age above 18).The speed difference was found to be same and not significant,where the distance headway difference for this case were found to be stastically extremely different.The first comparison between field(Ispat English medium school,pedestrian age below 18) to field study(PadmanavEnggcollege,pedestrians age above 18).The speed for this case were found to be same and not significant,the distance headway difference was found to be extremely significant.The third comparisionwas done with field (Ispat English medium school,pedestrian age below 18)and experimental study(N.I.T campus,single file mixed gender motion).For both speed and distance headway the statistical difference found to be extremely significant.

REFERENCES

- Chattaraj, U., Seyfried, A. and Chakroborty, P. (2009). *Comparison of Pedestrian Fundamental Diagram Across Cultures*. Advances in Complex systems, 12(3), pp. 393–405.

- Chattaraj, U., Chakroborty, P. and Seyfried, A. (2010). *Empirical Studies on Pedestrian Motion Through Corridors of Different Geometries*. In Proceedings of the 89th Annual Meeting of the Transportation Research Board, Washington, D.C, USA.

- Chattaraj, U. (2011). *Understanding Pedestrian Motion: Experiments and Modelling*. Ph.D. thesis. IIT Kanpur, India.

- Chattaraj U., Seyfried A., Chakroborty P.,Biswal M. (2013a). *Modelling single file pedestrian motion across cultures*. Procedia Social and Behavioral Sciences (104), Elsevier, Agra, India, pp. 698–707.

- Chattaraj U., Chakroborty P., Arumuga S. N. (2013b). *Empirical Studies on Impacts of Obstacle inside Corridor on Pedestrian Flow*. Procedia Social and Behavioral Sciences (104), Elsevier, Agra, India, pp. 668–677.

- Chattaraj, U., Chakroborty, P. and Seyfried, A. (2013c). *Some Empirical Studies on Evacuation from Halls*. In Proceedings of the 9th Conference on Traffic and Granular Flow, Springer, Moscow, Russia, pp. 207-216.

- Hankin, B.D. and Wright, R.A. (1958). *Passenger Flow in Subways*. Operational Research Quarterly, 9(2), pp. 81–88.

- Helbing, D., Bunza, L., Johansson, A. and Werner, T. (2005). *Self Organized Pedestrian Crowd Dynamics: Experiments, Simulations and Design Solutions*. Transportation Science, 39(1), pp. 1–24.

- Helbing, D., Johansson, A. and Al-Abideen, H.Z. (2007). *Dynamics of Crowd Disasters: An Empirical Study*. Physical Review E, 75(4), pp. 046109 (1–7).

- Henderson, L.F. and Lyons, D.J. (1972). *Sexual Differences in Human Crowd Motion*. Nature, 240(5380), pp. 353–355.

- Hoogendoorn, S.P. and Daamen, W. (2004). *Self–Organization in Walker Experiments*. In Proceedings of the 5th Symposium on Traffic and Granular Flow, (Eds.: Hoogendoorn, S.P., Luding, S., Bovy, P.H.L., Schreckenberg, M. and Wolf, D.E.), Springer, Delft, The Netherlands, pp. 121–132.

- Hoogendoorn, S.P. and Daamen, W. (2005). *Pedestrian Behavior at Bottlenecks*. Transportation Science, 39(2), pp. 147–159.

- Isobe, M., Adachi, T. and Nagatani, T. (2004). *Experiment and Simulation of Pedestrian Counter Flow*. Physica A, 336(3–4), pp. 638–650.

- Kretz, T., Gruenebohm, A., Kaufman, M., Mazur, F. and Schreckenberg, M. (2006). *Experimental Study of Pedestrian Counterflow in a Corridor*. Journal of Statistical Mechanics: Theory and Experiment, P10001.

- Mori, M. and Tsukaguchi, H. (1987). *A New Method for Evaluation of Level of Service in Pedestrian Facilities*. Transportation Research Part A, 21A(3), pp. 223–234.

- Morrall, J.F., Ratnayake, L.L. and Seneviratne, P.N. (1991). *Comparison of CBD Pedestrian Characteristics in Canada and Sri Lanka*. Transportation Research Record,

1294, Transportation Research Board, National Research Council, Washington, DC, USA, pp. 57–61.

- Navin, F.P.D. and Wheeler, R.J. (1969). *Pedestrian Flow Characteristics*. Traffic Engineering, 39(9), pp. 30–36.

- Older, S.J. (1968). *Movement of Pedestrians on Footways in Shopping Streets*. Traffic Engineering and Control , 10(4), pp. 160–163.

- Polus, A., Joseph, J.L. and Ushpiz, A. (1983). *Pedestrian Flow and Level of Service*. Journal of Transportation Engineering, ASCE, 109(1), pp. 46–56.

- Rastogi, R., Ilango, T. and Chandra, S. (2011a). *Design Implications of Walking Speed for Pedestrian Facilities*, Journal of Transportation Engineering, ASCE, 137(10), pp. 687-696.

- Rastogi, R., Chandra, S., Vamsheedhar, J. and Das, V. (2011b) *Parametric study of pedestrian speeds at midblock crossings.* Journal of Urban Planning and Development, ASCE, 137(4), pp. 381-389.

- Sahani R., Bhuyan P. (2013). *Level of Service Criteria of off-street Pedestrian Facilities in Indian Context using Affinity Propagation Clustering*. Procedia Social and Behavioral Sciences (104), Elsevier, Agra, India, pp. 718–727.

- Seyfried, A., Steffen, B., Klingsch, W. and Boltes, M. (2005). *The Fundamental Diagram of Pedestrian Movement Revisited*. Journal of Statistical Mechanics: Theory and Experiment, P10002.

- Seyfried, A., Passon, O., Steffen, B., Boltes, M., Rupprecht, T. and Klingsch, W. (2009). *New Insights into Pedestrian Flow through Bottlenecks*. Transportation Science, 43(3), pp. 395–406.

- Young, S.B. (1999). *Evaluation of Pedestrian Walking Speeds in Airport Terminals*. Transportation Research Record, 1674, Transportation Research Board, National Research Council, Washington, DC, USA, pp. 20–26.